# Homophily in Social Networks and Labor Market Outcomes

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Version: April 2010

We develop a labor matching model where information about vacant jobs is partly obtained through contacts. From this framework we study the correlation between some charateristics of the structure of social networks and labor market outcomes. Workers are embeded in different network structures according to their type -or origin. Following recent theoretical and empirical findings, we consider that two characteristics of network composition are endogenous for each type: homophily -the tendency to associate with individuals of the same type- and network size. These two characteristics are affected by changes in three key elements, the relative size of each group in the population, average preferences for same-type ties and biases in meetings. Our numerical simulations suggest a positive relation between network size and labor market outcomes, which is in line with the literature. Simulations however suggest something less expected, a positive correlation between homophily and labor market outcomes for members of the minority group. The relation is reversed for the majority group. We discuss conditions and explainations for this correlation. We furthermore notice that the way the three key elements we mentioned above affect labor market outcomes for each group is in line with the growing empirical literature on the subject.

*Key Words:* Social Networks, Information Transmission, Homophily, Unemployment.

*JEL Classification:* J15 ; J64 ; D83.

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# 1. INTRODUCTION

It is now widely admitted that information transmission about job vacancies through Social Networks -SN below, for short- affects labor market outcomes[2]. Yet, a very few studies have focused on the way SN affect inequalities between groups. We do not thus exactly know in which conditions members of ethnic minorities benefit or not from the fact that a part of jobs are found through contacts. The common belief about the impact of SN on inequality between groups in the labor market is that members of the majority group will benefit from word-of-mouth communication more than members of minority groups, unless members of the minority group are well organized. The work of Tassier & Menzcer (2008) -T&M below, for short- which constitute as far as we aware the single theoritical attempt to investigate this issue, tends to confirm this belief. T&M show from a controlled experiment that members of the minority group will clearly benefit from word-of-mouth communication about job vacancies only when SN are segregated[3] and since both members of the minority's SN and job networks[4] are tied into little clusters[5]. In some ways, they demonstrate that many conditions are request for information transfer about vacancies through contacts being at the advantage of members of the minority group against members of the majority group. For many reasons we will detail below, we contest this conclusion and construct a model where we show, unlike T&M, that information transfer through SN will most of the time benefit to members of the minority group against members of the majority group. In fact the study of T&M do not take into account recent findings from the literature on network formation which show that the level of segregation in SN vary with the relative size of each group in the population. Indeed, in T&M the level of segregation is the same for both of the two groups. Taking into account that segregation in SN for both types[6] vary with the relative size of each group, we show that by construction, communication through contacts will benefit, all other things being equal between the two groups, to members of the minority group. Before describing with more details our model and our main results, let us tell more about why the level of segregation in SN partly depend of the relative size of each group in the population.

In fact, recent works such as the one of Currarini Jackson & Pin (2009) -CJ&P below,

[2] See the seminal works of Rees (1966) and Granovetter (1973). See also Ioannides & Loury (2004) for a literature review on the subject.

[3] Segregation in SN reflects in T&M the fact that individuals tend to be tied with individual of the same type. The tendancy to form friendship with individual with similar characteristics is also often refered in the literature as "homophily" in SN. We thus can mention some "homophily rate" or "segregation rate" in any individual's SN.

[4] Jobs may be structured into networks. In this case, an employed individual will only transmit a job offer about job vacancy which is linked to his job. If jobs are not linked in the economy (the case where there are only independant workers), an employed individual will transmit an information on a vacancy he randomly heard about.

[5] This works only for a high enough level of segregation in SN and when members of the majority group, unlike members of the minority, are randomly tied. "Randomly tied" in T&M means that they are not linked into little group of four individuals where they all have frienship with each other.

[6] "Type" in our model will refer to ethnic related patterns.

for short, the work of Moody (2001) or the one of McPherson & al (2001), have shown that segretation in social relations depends on the ability of individual to realize their more or less strong preferences to form friendship with individual similar to themeselves[7]. Segregation in SN is in fact positively correlated, all other things being equal, with the relative size of the concerned group in the society even if meeting opportunity biases also play an important role as we will see below. T&M, without introducing segregation in SN in taking into account this feature, miss as a consequence some strong specificities of segregation in SN. In order to take into account with more precision segregation in SN, we rely upon the model of network formation of CJ&P. CJ&P have built a model where they replicate for each ethnic group in the population average homophily[8] rates -the proportion of individual of the same ethnic group among ties- and average number of contacts they observe in many US high schools[9] in function of the relative size of each group. More precisely, in CJ&P's model, network formation depend on three exogenous variables: the level of preferences for same type ties and two things which affect the ability of individuals to realize these preferences, meeting biases through same type and relative size of each group in the population. When both preferences and meeting biases are fixed, homophily varies with the relative size of each group in the population. Taking into account this model of network formation modify, as we show in our model, the results of T&M in relaxing the conditions for homophily in SN being at the advantage of the minority group.

Our theoretical model of the labor market with SN is inspired by the one of Calvò-Armengol & Zenou (2005) -C-A&Z below, for short- which has been modified by Ioannides & Soetevent (2006) -I&S below, for short. These last two models study the impact of the average number of contacts between workers in the economy on labor market performances[10]. We rely upon these theoretical works because they offer a more simple framework for numerical computations than the one of T&M. In the first part of our model we briefly illustrate how simultaneous variations in the three parameters we mentioned above influence for each type both the average homophily rate and average number of contacts. In the second part of the model[11], in a similar theoretical frame-

[7] One of the most pervasive feature observed in SN is the tendancy of individuals to associate with individuals similar to themselves. If age, gender or socioeconomic status are influencing characteristics of friendship formation, ethnic related patterns are by far the most influencing ones (see for instance Lewis & al, 2008; Grosseti, 2007; McPherson & al, 2001; Moody, 2001; Marsden, 1988). This legitimates the fact that "type" in our model refer to ethnic related patterns even if our results may also be tested for gender or socioeconomic status.

[8] Henceforth, we will mention "homophily" in SN as in CJ&P instead of "segregation" in SN.

[9] Their model feets very well with empirical observations about the two characteristics of networks we mentioned. Their data come from the Add Health inquiy set from 112 US high schools.

[10] C-A&Z study the impact of uniformly distributed number of contacts among workers whereas I&S study the impact of randomly ditributed number of contacts. C-A&Z find a critical size of networks from which the competition between worker in a network affect at the matching function. I&S do not find any congestion effect when the number of contact is not uniformly distributed among the population of workers. In the same subject see Wahba & Zenou (2005) for an empirical work with data from the 1998 Egyptian Labor Market Survey.

[11] There are no strategic links between labor market outcomes and the way networks form. In other words, network formation does not depend on any outcome expectations from the labor market.

work of the labor market as C-A&Z and I&S[12], we describe how these variations in both the number of contacts and homophily rates for each type modify job arrival rates and unemployment. We first deduce from our numerical simulations a positive relation between the number of contacts and labor market outcomes, which is in line with the literature. The second important observation is that, all other things being equal between the two groups, homophily leads to a higher job arrival rate for members of the minority group. This effect increases and then diminishes when the relative size of each group move closer. We moreover extend the analysis of our results in two directions. Looking further into the literature on SN and labor market outcomes for minorities, we first notice that introducing CJ&P's model of network formation into a model of the labor market will help us to give some more theoretical interpretations to recent empirical findings on the impact of SN on inequality between groups in the labor market. Indeed, many recent empirical studies insist on the fact that some factors, such as urban ethnic segregation, attachment to the culture of origin or relative size of a community in the population, influence individuals sociability and then their situation in the labor market -see for instance Battu & al (2010), Damm (2009), Hellerstein & al (2008), Pattachini & Zenou (2008), Edin & al (2003) and Conley & Topa (2002). Our results are going in the same way as the ones of these empirical studies[13]. The second extension consist in re-evaluating the positive effect of homophily in SN on labor market outcomes for the minority group when members of the minority group face hiring discriminations[14]. We show in this extension that biased homophily still have a positive effect but this effect is now surprisingly monotically increasing[15] when the size of the groups tend to be closer. Something noteworthy is however that the negative effect of hiring discrimination is largely stronger than the positive effect of homophily for member of the minority group. Even with a low level of discrimination, the situation of the minority is, unlike the case without hiring discrimination, clearly worse than the one of the majority.

## 2. NETWORK FORMATION

We assume that there are two types of individuals $i$ and $j$, (with two differents origins). We then have a population $N = N_i + N_j$ where $n_i = \frac{N_i}{N}$ and $n_j = \frac{N_j}{N}$ ($N_i$ is the number of individual of type $i$, $N_j$ is the number of individual of type $j$ and $N$ the total number of individuals in the population). Individuals of type $i$ form ties in function of the relative size of their group $n_i$ in the population, but also in function of

[12] A theoretical matching model of the labor market *à la* Pissarides (2000) with SN.

[13] Preferences for same type ties have a negative impact on labor market outcomes for members of the minority group whereas a rise in meeting biases through same type -which could for instance be associated to a rise in the global ethnic segregation in the society- have a positive impact for members of the minority group

[14] Arrow (1998) suggested that the impact of SN on minority's situation in the labor market should not be studied separatly from the study of hiring discrimination or any hiring penalty.

[15] This is true in every cases excepted one (see Fig.5).

their preference to form tie with their type $i$ and in function of their meeting opportunity biases (going to cultural institutions, meeting through friends, etc.).

## 2.1. The basic mecanism

We consider a matching process between individuals *à la* CJ&P. Each individual maximize his utility $U(s_i, d_i)$ which is increasing and concave and where $s_i$ and $d_i$ are respectively for an individual of type $i$ the number of contact of the same type $i$ and of the other type $j$. In fact, $N_i$ individuals of type $i$ enter in the matching process and form one tie in each period, the same for the $N_j$ individuals of type $j$. According to his utility and his constraint, each individuals decides to enter $l$ times in the process to get contacts. At each time individuals meet other individuals of both types. In the end of the process individuals of type $i$ went on average $l_i$ times in the process and have each formed $l_i$ ties with $l_i = s_i + d_i$. Then, all individual of type $i$ considered have formed $N_i \times l_i$ contacts.

## 2.2. Preferences and meeting opportunity biases

### *2.2.1. Preferences for same-type ties*

We consider the following utility function, $U(s_i, d_i) = (s_i + \gamma_i d_i)^{\alpha_i}$ where $\gamma_i \in [0, 1]$ depreciates the utility of a contact with an individual of type $j$ for individuals of type $i$ and $\alpha_i \in [0, 1]$ is a coefficient which catches the decreasing marginal utility of the total number of contacts. We consider $\alpha_i = \alpha_j = \alpha$. Doing so, type $i$ and type $j$ will have the same satisfaction for the total number of ties they form. Moreover, when $\gamma_i < 1$, each type give more value to a contact with an individual of the same type.

Individuals of type $i$ choose to enter in the matching process $l_i$ times in function of both $U(s_i, d_i)$ and the cost $c_i$ of entering the process. Each individual of type $i$ meets an individual of the same type with probability $q_i$ each time he enters the process and an individual of the other type with probability $(1 - q_i)$.

Knowing the probability $q_i$ to meet someone of the same type for type $i$, we have $s_i = l_i q_i$ and $d_i = l_i(1 - q_i)$. Then

$$U(l_i q_i, l_i(1 - q_i)) = (l_i q_i + \gamma_i l_i(1 - q_i))^{\alpha} \tag{1}$$

If $c_i \in [0,1]$ is the cost to enter the process, individuals of type $i$ solve the following program:

$$\underset{l_i}{Max} \left[ U(l_i q_i, l_i(1-q_i)) - c_i l_i \right] \tag{2}$$

As for $\alpha$, we henceforth assume that $c_i = c_j = c$.

From (2) and (1) we find that the optimal number of contact $l_i^*$ for an agent of type $i$ is

$$l_i^* = \left(\frac{\alpha}{c}\right)^{\frac{1}{1-\alpha}} \left( \left(1-\gamma_i\right) q_i + \gamma_i \right)^{\frac{\alpha}{1-\alpha}} \tag{3}$$

Note that $\frac{\partial l_i^*}{\partial \gamma_i} = \left(\frac{\alpha}{c}\right)^{\frac{1}{1-\alpha}} \underbrace{(1-q_i)}_{\geq 0} \left( \underbrace{(1-\gamma_i)}_{\geq 0} q_i + \gamma_i \right)^{\frac{2\alpha-1}{1-\alpha}} \Longleftrightarrow \frac{\partial l_i^*}{\partial \gamma_i} \geq 0$, that is to say the number of contact rise when preferences decrease ($\gamma_i \to 1$). In the same way, the number of contact rises when $q_i \to 1$ because as we see $\frac{\partial l_i^*}{\partial q_i} = \left(\frac{\alpha}{c}\right)^{\frac{1}{1-\alpha}} \underbrace{(1-\gamma_i)}_{\geq 0} \left( \underbrace{(1-\gamma_i)}_{\geq 0} q_i + \gamma_i \right)^{\frac{2\alpha-1}{1-\alpha}}$

$\Longleftrightarrow \frac{\partial l_i^*}{\partial q_i} \geq 0$.

*2.2.2. Biases in meeting opportunity*

Without any meeting biases, since there is a large number of agents of each type, individuals of type $i$ and those of type $j$ have the same probability to meet an individual of type $i$. $q_{ii} = q_{ji} = q_i = \frac{M_i}{M}$ stands for this probability, where $M_i = N_i l_i^*$ is the total number of matching individuals of type $i$ make and where $M$ is the total number of matching individuals of both type $i$ and $j$ make so that $M = N_i l_i^* + N_j l_j^*$. In the same way we have $q_{jj} = q_{ij} = q_j = \frac{M_j}{M}$.

As CJ&P we introduce biases in meeting opportunity for each type toward individuals of the same type. This meeting bias could for instance represent the more or less important average physical or geographical distance between individual of the same type as mentionned in Conley and Topa (2002). If $q_{ii}$ and $q_{ij}$ are respectively for an individual of type $i$ the probability to meet an individual of type $i$ and $j$, then, instead of having $q_i + q_j = 1$, which would be logical with $q_i = \frac{M_i}{M}$ and $q_j = \frac{M_j}{M}$ because $M_i + M_j = M$, we have

$$q_i^{\beta_i} + q_j^{\beta_j} = 1 \tag{4}$$

where $\beta_i > 0$ represent the meeting bias through same type for type $i$ and $\beta_j > 0$ the meeting bias through same type for type $j$. Probabilities to meet individual of the other type are respectively $(1-q_i)$ for individuals of type $i$ and $(1-q_j)$ for individuals of type $j$.

$\beta_i > 1$ implies for instance for individuals of type $i$ that they will have higher probability to meet individual of the same type than at random. When $\beta_i > \beta_j$, biases in meeting opportunity are higher for type $i$.

### 2.3. Additionnal condition

Since the total number of contacts formed by individuals of type $i$ with individuals of type $j$ is by definition the same as the total number of contacts formed by individuals of type $j$ with type $i$, we have

$$(M_i)(1-q_i) = (M_j)(1-q_j)$$

$\Longleftrightarrow$

$$(N_i l_i^*)(1-q_i) = \left(N_j l_j^*\right)(1-q_j)$$

$\Longleftrightarrow$

$$n_i l_i^* (1-q_i) = (1-n_i)\, l_j^* \left(1 - \left(1 - q_i^{\beta_i}\right)^{\frac{1}{\beta_j}}\right) \tag{5}$$

This condition (5) will help us to solve the model.

### 2.4. Homophily rate and density of networks for each type

Individuals of type $i$ finally form on average $s_i + d_i$ contacts. In the same way individuals of type $j$ form $s_j + d_j$ contacts. From all the previous equations we have

$$\begin{aligned} s_i &= s_i(N_i, \gamma_i, \beta_i) = l_i^* \times q_i \qquad (6) \\ d_i &= d_i(N_i, \gamma_i, \beta_i) = l_i^* \times (1-q_i) \end{aligned}$$

and

$$\begin{aligned} s_j &= s_j(N_j, \gamma_j, \beta_j) = l_j^* \times q_j \qquad (7) \\ d_j &= d_j(N_j, \gamma_j, \beta_j) = l_j^* \times (1-q_j) \end{aligned}$$

We fix $\gamma_i, \beta_i, \gamma_j$ and $\beta_j$. We have to find $l_i^*(n_i)$, $q_i(n_i)$, $l_j^*(n_i)$ and $q_j(n_i)$. To do so, we rely upon (1), (3), (4) and (5) and solve the following system:

$$\begin{cases} l_i^* = \left(\frac{\alpha}{c}\right)^{\frac{1}{1-\alpha}} \left(\left(1-\gamma_i\right) q_i + \gamma_i\right)^{\frac{\alpha}{1-\alpha}} \\ q_i^{\beta_i} + q_j^{\beta_j} = 1 \\ l_j^* = \left(\frac{\alpha}{c}\right)^{\frac{1}{1-\alpha}} \left(\left(1-\gamma_j\right)\left(1-q_i^{\beta_i}\right)^{\frac{1}{\beta_j}} + \gamma_j\right)^{\frac{\alpha}{1-\alpha}} \\ n_i l_i^* \left(1-q_i\right) = \left(1-n_i\right) l_j^* \left(1-\left(1-q_i^{\beta_i}\right)^{\frac{1}{\beta_j}}\right) \end{cases} \quad (8)$$

We cannot analytically solve (8) to obtain $l_i^*$, $q_i$, $l_j^*$ and $q_j$, that is why as CJ&P we use simulation. We fix $\alpha$ and $c$ such that the total number of contacts each individual finally forms approximatly vary between 10 and 20. This correspond to current figures used in comparable researches (see Fontaine, 2008, Ioannides et Soetevent, 2006).

We represent in the Fig.1 homophily curves $H_i(n_i) = \frac{s_i}{s_i+d_i}$ and in the Fig.2 the representative curves $l_i(n_i)$ of the number of contacts formed by individuals of type $i$, with $\gamma$ and $\beta$ the same for the two types. In the Fig.1 we observe the impact of simultaneous variation in $n_i$ and $\gamma$, and also in $n_i$ and $\beta$ on $H_i(n_i)$. We see that $H_i$ is always increasing in $n_i$. Moreover, when $\beta > 1$, a rise in preferences ($\gamma \to 0$) have a negative impact on $H_i$ if type $i$ is the minority. But when $0 \leq \gamma < 1$, a rise in $\beta$ has a positive impact on $H_i$. When $0 \leq \gamma < 1$ and $\beta > 1$, $H_i(n_i)$ is an increasing and concave function.

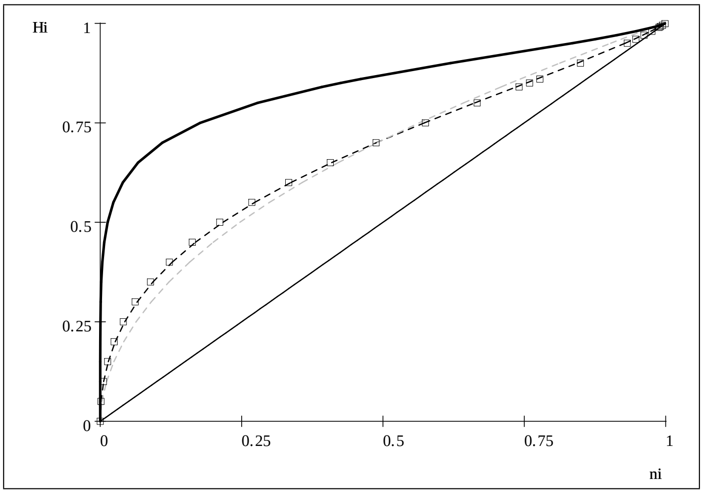


Fig.1 Homophily rate $H_i\,(n_i)$.

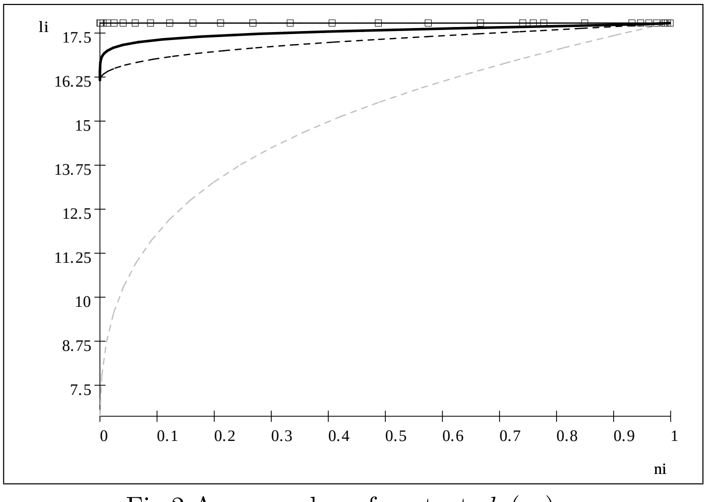


Fig.2 Average nbr. of contacts $l_i\,(n_i)$.

**No biases** (black thin solid) : $\gamma = 1$ & $\beta = 1$
**Medium biases** (black dashes) : $\gamma = 0.8$ & $\beta = 2$
**Strong pref. and medium biases in meeting** (gray dashes) $\gamma = 0.1$ & $\beta = 2$
**Medium pref. and strong biases in meeting** (black thick solid) $\gamma = 0.8$ & $\beta = 5$
**Only biases in meeting** (boxes) $\gamma = 1$ & $\beta = 2$

The total number of contacts $l_i\,(n_i)$ an individual of type $i$ has does not vary exactly in the same way as $H_i\,(n_i)$. Both $l_i\,(n_i)$ and $H_i\,(n_i)$ are increasing in $n_i$. Furthermore, when $\gamma$ exists ($0 < \gamma < 1$), a rise in $\beta$ has a positive impact on bothe $l_i\,(n_i)$ and $H_i\,(n_i)$. But when $\beta > 1$, a rise in preferences ($\gamma \to 0$) clearly have a negative impact on $l_i$ whereas it has a little negative impact on homophily rate when type $i$ is the minority and a little positive impact when type $i$ stands for the majority.

## 3. THE LABOR MARKET

We now aim at estimating the impact of the variation in both homophily rate and number of contacts on job arrival rate and unemployment for each type. Heterogeneity only comes from the three factors we mentionned above. The labor market with social network we build steams from C-A&Z's matching model *à la* Pissarides (2000) with discrete time periods[16], word-of-mouth communication about vacant jobs and an explicit network structure which come from CJ&P's model as decribed in the first section. Our model is different from C-A&Z's one in allowing for individuals with different network structure. It follows the extension of C-A&Z's model proposed by I&S, excepted that we do not consider random social network as in I&S but only two kind of workers with social networks reflecting individuals preference about friendship. In fact our model is positionned between C-A&Z and I&S models because we have two kinds of network but we keep a uniformly distributed number of contact for each type instead of Poisson distribution as in I&S.

However, as in C-A&Z an I&S we have identical workers - they are similar excepted that they are tied in function of their type - and identical firms. At the begining of each time period $t_n$ each worker receives information about vacant job in a formal way (they can go to employment agencies, read newspaper, search through the web, etc.) with probability $v_{t_n}$. They also may receive information through contacts, this is what we call the "informal way" of receiving information. We describe the mecanism below. Each worker may lose his job with probability $b$. We denote $u_t$ the global unemployment rate at the end of period $t$. Finally, as in C-A&Z an I&S, we assume that newly-employed workers produce $y_0$ at the first period they are employed and $y_1$ in the next periods with $y_0 < y_1$. In the same way they earn $w_0$ and $w_1$. This induces that employed worker have not any interest to keep a job offer for themselve.

### 3.1. Transmission of job offer through contacts

We assume discrete time so that at each time period $t_n$ an employed worker who receive a job offer will choose only one of his unemployed contacts. As in C-A&Z one may interprete this as if an employed woker talk to only one of his direct unemployed contact a day. This imply that at each period, a worker of type $i$ who receive a job offer

[16] See Fontaine (2008) for a Matching model with SN and continuous time.

will select at random one of his $s_i u_i + d_i u_j$ unemployed contact, $u_i$ and $u_j$ being the unemployement rate of individual of type $i$ and $j$.

The transmission proccess may then be summarized as follow. Consider *ego*, an unemployed individual of type $i$. Only employed *ego*'s contacts will transmit him information about jobs. At the steady state, let us note $u_{ei} = H_i u_i + (1 - H_i)\, u_j$ the average unemployment rate in the network of an individual of type $i$. $u_{ei}$ may be the average unemployment rate in one of *ego*'s employed contact of type $i$. Then the probability that *ego*'s employed contact who hold a job offer has $k$ other unemployed contact and choose *ego* among all these individuals is

$$\sum_{k=0}^{l_i-1} \frac{1}{k+1} \binom{l_i - 1}{k} (1 - u_{ei})^{l_i-1-k}\, u_{ei}^k = \frac{1 - (1 - u_{ei})^{l_i}}{u_{ei} l_i} \tag{9}$$

where $\binom{l_i-1}{k} (1 - u_{ei})^{l_i-1-k}\, u_{ei}^k$ is the binomial distribution standing for the exact probability that there are $k$ unemployed individual in the network of an employed individual of type $i$. $(1 - u_i)\, v \frac{1-(1-u_{ei})^{l_i}}{u_{ei} l_i}$ is then the probability that an individual of type $i$ is employed, receive a job offer and transmit it to *ego*.

If *ego* is an unemployed individual of type $i$, he has $s_i$ contacts of his type. $\left(1 - (1 - u_i)\, v \frac{1-(1-u_{ei})^{l_i}}{u_{ei} l_i}\right)^{s_i}$ is then probability that any of these $s_i$ contacts do not transmit to *ego* an information about a job offer. The probability $\varphi_{ii}$ to receive a job offer through a contact of the same type for an individual of type $i$ is then $1 - \left(1 - (1 - u_i)\, v \frac{1-(1-u_{ei})^{l_i}}{u_{ei} l_i}\right)^{s_i}$. In the same way we obtain the probability $\varphi_{ij}$ that *ego* receive a job offer through a contact of the other type $j$, $1 - \left(1 - (1 - u_j)\, v \frac{1-(1-u_{ej})^{l_j}}{u_{ej} l_j}\right)^{d_i}$, where $u_{ej} = H_j u_j + (1 - H_j)\, u_i$.

We finally have the probability $\varphi_i$ for an individual of type $i$ to receive a job offer through network

$$\varphi_i = \varphi_{ii} + \varphi_{ij}$$

and after simplification

$$\varphi_i = 2 - \left(1 - (1 - u_i)\, v \frac{1 - (1 - u_{ei})^{l_i}}{u_{ei} l_i}\right)^{s_i} - \left(1 - (1 - u_j)\, v \frac{1 - (1 - u_{ej})^{l_j}}{u_{ej} l_j}\right)^{d_i} \tag{10}$$

In the same way we find

$$\varphi_j = 2 - \left(1 - (1 - u_j)\, v \frac{1 - (1 - u_{ej})^{l_j}}{u_{ej} l_j}\right)^{s_j} - \left(1 - (1 - u_i)\, v \frac{1 - (1 - u_{ei})^{l_i}}{u_{ei} l_i}\right)^{d_j} \tag{11}$$

From these results, one may deduce the probability $p_i$ that an unemployed individual of type $i$ receive a job offer. Taking into account both formal and informal method we have

$$p_i = v + (1 - v)\,\varphi_i \tag{12}$$

In the same way we find

$$p_j = v + (1 - v)\,\varphi_j \tag{13}$$

### 3.2. The matching function

The corresponding matching function takes into account the two types such that

$$m\,(u_i, u_j, v, n_i) = n_i u_i p_i + (1 - n_i)\, u_j p_j \tag{14}$$

The job filling rate is defined as follow

$$f\,(u_i, u_j, v, n_i) = \frac{m\,(u_i, u_j, v, n_i)}{v}$$

and the probability that a vacant job is filled by an unemployed individual of type $i$ is

$$f_i\,(u_i, u_j, v, n_i) = \frac{n_i u_i p_i}{m\,(u_i, u_j, v, n_i)}$$

and

$$f_j\,(u_i, u_j, v, n_i) = \frac{(1 - n_i)\, u_j p_j}{m\,(u_i, u_j, v, n_i)}$$

### 3.3. The steady-state labor market equilibrium

#### *3.3.1. The free entry condition*

The expected profit $\Pi_{E_{it_n}}$ of a filled job by a worker of type $i$ who have on average $s_i + d_i$ contacts is at $t_n$:

$$\Pi_{E_{it_n}} = y_1 - w_{1_i} + \frac{1}{1+r}\left[(1-b)\Pi_{E_{it_{n+1}}} + b\Pi_{V_{t_{n+1}}}\right] \tag{15}$$

where $y_1$ is the productivity of an employed individual, $w_{1_i}$ is the wage of an individual of type $i$ and $\Pi_{V_{t_{n+1}}}$ is the expected profit of a vacant job for a firm at $t_{n+1}$. Moreover, if $f$ is the rate at which a firm fill a vacant job and $f_i$ the probability to fill a job through a type $i$ unemployed individual, then $\Pi_{V_{t_n}}$ is:

$$\Pi_{V_{t_n}} = -h + (1-f)\frac{1}{1+r}\Pi_{V_{t_{n+1}}} + f\left[y_0 - w_0 + \frac{1}{1+r}\left((1-b)\times E_{f_{i,j}}\left[\Pi_{E_{i,jt_{n+1}}}\right] + b\Pi_{V_{t_{n+1}}}\right)\right] \tag{16}$$

where $h$ is the cost of a vacant job for firms, $r$ the interest rate and where the expectation $E_{f_{i,j}}$ is taken with respect to $f_{i,j}(u_i, u_j, v, n_i)$.

At the steady state we have $\Pi_{E_{it_n}} = \Pi_{E_{it_{n+1}}} = \Pi_{E_i}$ and $\Pi_{V_{t_n}} = \Pi_{V_{t_{n+1}}} = \Pi_V$. Moreover, with the free entry condition we have $\Pi_V = 0$. With $y_0 = w_0 = 0$, these conditions lead (16) to $h\frac{1+r}{1-b} = f \times E_{f_{i,j}}\left[\Pi_{E_{i,j}}\right]$. From (15) we deduce $\Pi_{E_i} = (y_1 - w_{1_i})\frac{1+r}{r+b}$ and $\Pi_{Ej} = \left(y_1 - w_{1_j}\right)\frac{1+r}{r+b}$. We then have

$$h\frac{r+b}{1-b} = E_{f_{i,j}}\left[f \times \left(y_1 - w_{1_{i,j}}\right)\right] \tag{17}$$

### *3.3.2. Wages determination*

*Utility of unemployed individuals :*

If $W_{U_{it_n}}$ is type $i$ unemployed individual utility, $r$ is the real interest rate, $w_0$ is the wage of an individual entering employment and $W_{E_{it_{n+1}}}$ the utilty of a type $i$ employed individual at $t_{n+1}$, then

$$W_{U_{it_n}} = \frac{1}{1+r}(1-p_{it_n})W_{U_{it_{n+1}}} + p_{it_n}\left[w_0 + \frac{1}{1+r}\left((1-b)W_{E_{it_{n+1}}} + bW_{U_{it_{n+1}}}\right)\right]$$

At the steady state, $W_{E_{it_n}} = W_{E_{it_{n+1}}} = W_{E_i}$ and $W_{U_{it_n}} = W_{U_{it_n}} = W_{U_i}$. We finally have

$$W_{U_i} = \frac{1}{1+r}(1-p_i)W_{U_i} + p_i\left[w_0 + \frac{1}{1+r}\left((1-b)W_{E_i} + bW_{U_i}\right)\right] \tag{18}$$

*Utility of employed individuals :*

Utility $W_{E_{it_n}}$ of a type $i$ employed individual is:

$$W_{E_{it_n}} = w_{1_i} + \frac{1}{1+r}\left[(1-b)W_{E_{it_{n+1}}} + bW_{U_{it_{n+1}}}\right]$$

then at the steady state

$$W_{E_i} = w_{1_i} + \frac{1}{1+r}\left[(1-b)W_{E_i} + bW_{U_i}\right] \tag{19}$$

with $w_1$ the wage and $b$ the job destruction rate.

*Finding wages :*

From (19) and (18) we find at the steady state

$$W_{E_i} - W_{U_i} = \frac{1+r}{r+b+p_i\,(1-b)} w_{1_i} \tag{20}$$

If we note $x \in (0,1)$ the surplus share attributed to workers and if wages are Nash bargained we have

$$w_{1_i} = \arg\max \left(W_{E_i} - W_{U_i}\right)^x \left(\Pi_{E_i} - \Pi_V\right)^{1-x}$$

We then have the following first order condition

$$(1-x)\left(W_{E_i} - W_{U_i}\right) = x\left(\Pi_{E_i} - \Pi_V\right) \tag{21}$$

From (21), (20) and (15) and from the free entry condition $\Pi_V = 0$,

$$(1-x)\left(W_{E_i} - W_{U_i}\right) = x\left(\Pi_{E_i} - \Pi_V\right)$$

$\Longleftrightarrow$

$$w_{1_i} = \frac{x\,(r+b) + xp_i\,(1-b)}{r+b+xp_i\,(1-b)} y_1 \tag{22}$$

In the same way we find

$$w_{1j} = \frac{x\,(r+b) + xp_j\,(1-b)}{r+b+xp_j\,(1-b)} y_1 \tag{23}$$

*3.3.3. Finding the vacancy rate at the steady state*

From (22), (23) and (17) we find

$$E_{f_{i,j}}\left[\frac{fy_1}{r+b+x\,(1-b)\,p_{i,j}}\right] = \frac{h}{(1-b)\,(1-x)} \tag{24}$$

### 3.3.4. *The steady-state unemployment rate*

At the begining of each period $t_n$, a proportion of type $i$ unemployed individuals find a job with probability $p_{it_n}$. A rate $u_{it_{n-1}}p_{it_n}$ of individual of type $i$ thus enters employment at the begining of $t_n$, where $u_{it_{n-1}}$ is the unemployment rate of a type $i$ individual when entering $t_n$. Moreover, we have a rate $1-u_{it_{n-1}}$ of type $i$ employed individuals at the begining of $t_n$. If, at each period, some employed individuals lose their job at rate $b$, individual of type $i$ lose their job at $t_n$ at rate $b\left(\left(1-u_{it_{n-1}}\right)+u_{it_{n-1}}p_{it_n}\right)$.

Evolution of unemployment between $t_n$ and $t_{n-1}$ is equal to the difference between those who have entered unemployment at the beginig of period $t_n$ and those who have lost their job at the end of $t_n$, then

$$u_{it_n}-u_{it_{n-1}}=b\left(\left(1-u_{it_{n-1}}\right)+u_{it_{n-1}}p_{it_n}\right)-u_{it_{n-1}}p_{it_n}$$

We then have, at the steady state, with $u_{it_n}=u_{it_{n-1}}=u_i$, and $p_{it_n}=p_{it_{n+1}}=p_i$

$$u_i=\frac{b}{p_i\left(1-b\right)+b} \tag{25}$$

and

$$u_j=\frac{b}{p_j\left(1-b\right)+b} \tag{26}$$

Moreover, we find the steady-state average unemployment rate

$$u=n_iu_i+\left(1-n_i\right)u_j \tag{27}$$

and

$$u=\frac{b}{\left(1-b\right)p+b}$$

## 3.4. Calibration

We start from the following system to calibrate our model for types $i$ and $j$ -see appendix A for more details about the choice of parameters chosen for calibration:

$$
\begin{cases}
E_{f_{i,j}}\left[\frac{fy_1}{r+b+x(1-b)p_{i,j}}\right]=\frac{h}{(1-b)(1-x)} \ (24) \\
W_{U_i}=\frac{1}{1+r}\left(1-p_i\right)W_{U_i}+p_i\left[w_0+\frac{1}{1+r}\left(\left(1-b\right)W_{E_i}+bW_{U_i}\right)\right] \ (18) \\
W_{E_i}=w_{1_i}+\frac{1}{1+r}\left[\left(1-b\right)W_{E_i}+bW_{U_i}\right] \ (19) \\
\Pi_{E_i}=y_1-w_{1_i}+\frac{1}{1+r}\left[(1-b)\Pi_{E_i}+b\Pi_V\right] \ (15) \\
u_i=\frac{b}{p_i(1-b)+b} \ (25) \\
u_j=\frac{b}{p_j(1-b)+b} \ (26) \\
u=n_iu_i+\left(1-n_i\right)u_j \ (27) \\
w_{1_i}=\frac{x(r+b)+xp_i(1-b)}{r+b+xp_i(1-b)}y_1 \ (22) \\
w_{1j}=\frac{x(r+b)+xp_j(1-b)}{r+b+xp_j(1-b)}y_1 \ (23) \\
p_i=v+\left(1-v\right)\varphi_i \ (12) \\
p_j=v+\left(1-v\right)\varphi_j \ (13)
\end{cases}
$$

### 3.5. Simulation results and interpretation

We choose a set of value for $\gamma$ and $\beta$ in order to illustrate the impact of both the variation in preferences and meeting opportunities biases on job arrival rate and unemployment rate.

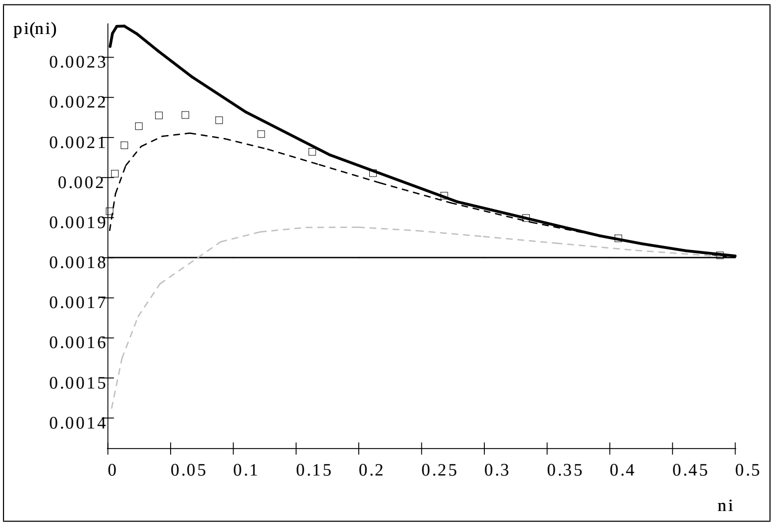


Fig.3 Job arrival rate for minority $p_i(n_i)$.

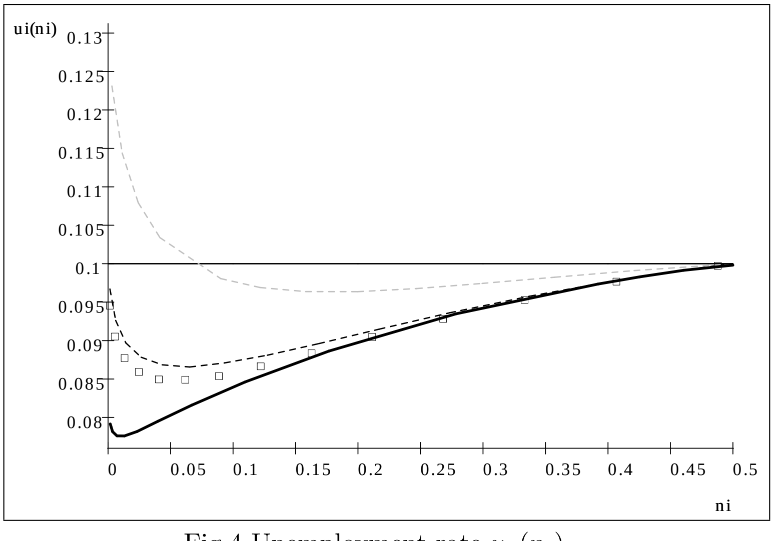


Fig.4 Unemployment rate $u_i(n_i)$.

**No biases** (black thin solid) : $\gamma = 1$ & $\beta = 1$

**Medium biases** (black dashes) : $\gamma = 0.8$ & $\beta = 2$

**Strong pref. and medium biases in meeting** (gray dashes) $\gamma = 0.1$ & $\beta = 2$

**Medium pref. and strong biases in meeting** (black thick solid) $\gamma = 0.8$ & $\beta = 5$

**Only biases in meeting** (boxes) $\gamma = 1$ & $\beta = 2$

#### 3.5.1. *The main observations*

When biases do not exist (see in Fig.3 and Fig.4 the black thin solid, $\gamma = 1$ and $\beta = 1$), there are not any variation in both the job arrival rate and the unemployment rate. Indeed, there are not any reason that information flows differs between individuals of type $i$ and $j$ as they have the same number of total contacts and the same number of contacts of each type (see Fig.1 and Fig.2). Thus, whatever the size of the groups $n_i$, individuals have the same probability to receive a job offer.

*Members of the minority group are advantaged:*

Since biases in preferences and meetings exit ($0 < \gamma < 1$ and $\beta > 1$) and since a part of information circulate through SN, we observe that individuals from the minority group are most of the time avantadged as compared with the average situation in the economy[17]. In other word it seems that the existence of biases in preferences and meetings benefit most of the time to members of the minority group -excepted for small groups with high preferences, see the case with $\gamma = 0.1$ in gray dashes.

*Non-monotonicity of the job arrival rate curve:*

An other important point is, when both biases in preferences and meetings exit, that a rise of the relative size of the minority group induce an increasing and decreasing form of the job arrival rate curve[18] -see Fig.3 and Fig.4. Why is thus the minority advantadged, why do the job arrival rate curve have this increasing and decreasing form and what are the mechanisms induced by the variations in $n_i$, $\gamma$ and $\beta$?

#### 3.5.2. *What are the impact of variations in homophily, in number of contacts and in relative size of groups?*

Considering the structure of our model, only three parameters have a direct impact on labor market outcomes, the homophily rate $H_i(n_i)$, the total number of contacts $l_i(n_i)$ and the relative size of each groups which may be resumed by $n_i$. Fig.1 and Fig.2 give information about the way $n_i$, $\gamma$ and $\beta$ influence $H_i(n_i)$ and $l_i(n_i)$. We also know from the literature - see C-A&Z and I&S - that the number of contacts $l_i(n_i)$ have in this type of model a positive effect on job arrival rate. We nevertheless do not know anything about the effect of $H_i(n_i)$ and about the combined effect of $l_i(n_i)$ and $H_i(n_i)$ on job arrival rates. To better understand the global mechanism at work we compare situations with différents $n_i$, $\gamma$ and $\beta$. From this we deduce the effect of the existance

[17] The average situation in the economy may be compared to the situation where there are neither biases in meetings nor biases in preferences ($\gamma$ and $\beta$ are equal to 1). Note that this will change when we will consider below a case with hiring discrimination for members of the minority group.

[18] The relation is inverse for unemployment.

of biased homophily - $H_i(n_i) \neq n_i$ - on job arrival rate. Once the effect of $H_i(n_i) \neq n_i$ on labor market is clearly known, one may interprete the global effect of $H_i(n_i)$, $l_i(n_i)$ and $n_i$.

*The impact of* $H_i(n_i)$*:*

An interesting case is the one with biases in meetings only (see the curve shaped with boxes, $\gamma = 1$ and $\beta = 2$). From Fig.1 we observe that in this case $H_i(n_i) > n_i$, which means that there are biased homophily[19]. Moreover, one may observe from Fig.2 that, with biases in meetings only, $l_i(n_i)$ is constant. Homophily is then biased whereas all individuals have the same number of contacts ($l_i$ is neutral). We then use this case to control for the effect of $H_i(n_i) > n_i$. We observe from Fig.3 that the concave increasing and decreasing form of the job arrival rate curve is conserved. The fact that $H_i(n_i) > n_i$ is then sufficient to explain both the fact that members of the minority group are advantaged and the increasing and decreasing form of the job arrival rate curve for members of the minority group when $n_i$ rise. Even if we already have some information from the literature about it, let us now discuss the effect of $l_i(n_i)$.

*The impact of* $l_i(n_i)$*:*

Are our simulation results about the effects of the number of contacts on labor market outcomes in line with the literature on social networks? We know from the theoretical literature that a rise in $l_i(n_i)$ have a positive effect on job arrival rate[20]. But what happens when homophily in SN exist? Two cases from the previous graphs may be compared to confront our result with the literature results. From Fig.3 one may notice that the case with medium biases (see black dashes, $\gamma = 0.8$ and $\beta = 2$) is a little less efficient for the minority group than the case with biases in meeting only (see boxes, $\gamma = 1$ and $\beta = 2$). We see from Fig.1 that the homophily rate $H_i(n_i)$ is not different between these two cases. The number of contacts is however a little higher for the case with meeting biases only (see Fig.2). The case with higher level of contacts being advantageous for members of the minority group, we deduce that the number of contact $l_i(n_i)$ have in our model a positive effect on job arrival rate for minority. This positive effect seems to be confirmed by another comparison, the one between the two cases we have just mentionned above and the case with strong preferences and medium biases in meeting (gray dashes, $\gamma = 0.1$ and $\beta = 2$). Indeed, with strong preferences ($\gamma = 0.1$) homophily rate does not differ a lot with the two previous cases (see Fig.1) whereas the number of contacts an individual create is strongly affected (see Fig.2). Our simulation framework only allow us to confirm that our model seems to be in line with the literature.

[19] Biases homophily means that at each giving point $(n_i, n_j)$, expected when $n_i \neq n_j$, individuals of type $i$ and $j$ do not have the same number of contacts of each type.

[20] Let us bring to mind that in C-A&Z, when contacts are uniformly distributed, we have a positive correlation between density of networks and job arrival rate until some value of the density of SN in the economy. Yet, in the same theoretical framework, I&S have shown that when number of contacts each individual has is randomly distributed, the relation remains increasing only.

It does not allow us to conclude about the fact that this positive correlation between the number of contacts and job arrival rate is due to homophily[21] or the fact that we do not consider a high enough number of contacts[22].

*The impact of $n_i$:*

What finally about the direct impact of $n_i$? It seems that a variation in $n_i$ only, when there is no biases (it means when $H_i(n_i) = n_i$ and $l_i(n_i)$ is constant) does not lead to any variation in the job arrival rate (see the black thin solid in Fig.3). From this we conclude that a variation in $n_i$ have a direct impact on job arrival rate only when $H_i(n_i) \neq n_i$ and when $l_i(n_i)$ is not constant.

Some of the mechanisms at work have then clearly been identified. The impact of $l_i(n_i)$ is well understood, individuals benefit from a rise in $l_i(n_i)$ in receiving a larger flow of information about vacant jobs. $H_i(n_i)$ have a positive impact on job arrival rate for the minority. But how now explain the direct impact of $H_i(n_i)$ on labor market outcomes and what are the economic intuitions behind the increasing and decreasing form of the job arrival rates curves observe in Fig.3? Let us now explain in a more intutive way the combined impact of variations in $n_i$ and $H_i(n_i)$ on job arrival rate.

### *3.5.3. Why do the existence of biased homophily tend to advantage the minority group?*

Two important questions must finally be clarified : why is the minority advantaged and how the increasing and decreasing form of the job arrival rates curves could be explained? We know from the previous discussion that the answer comes from the explaination of the consequences of the variations in $H_i(n_i)$ on labor market outcomes.

*Explanation for the positive correlation between homophily and labor market outcomes for members of the minority group:*

As job information is uniformly distributed through the formal channel to individuals whatever their type[23], the advantage of the minority group obviously comes from difference in the structure of networks. Thus, looking into equations (12) and (13), when $n_i < 0.5$, we have $\varphi_i(n_i) > \varphi_j(n_i)$. Looking into $\varphi_i(n_i)$ and $\varphi_j(n_i)$ -see equations (10) and (11)- we see that the single differences between theses two expressions are the value of the exponents $s_i$, $d_i$, $s_j$ and $d_j$. When $n_i < 0.5$ -type $i$ is the minority- we observe from Fig.1 that minority's networks are more mixed (lower homophily rate) than majority's

[21] I&S have shown that when considering randomly distributed number of contacts accross the population of workers, we have an increasing relation between global job arrival rate and the average number of contacts of workers in the economy.

[22] Indeed, C-A&Z find a critical network size above which the job arrival rate decrease.

[23] The probability $v$ to receive a job offer through formal channel is the same in equations (12) and (13).

networks. In other words, distribution of conctact is better balanced for type $i$ ($s_i$ and $d_i$ are not to much different) than for type $j$ ($s_j$ is very high whereas $d_j$ is not very far from zero). This means that more opened or mixed group (who can receive job offer through contacts of both type) is advantaged. Thus, in our model, homophily benefit to members of the minority as they have by construction a lower homophily rate than members of the majority. The difference between the two groups tend to decrease as homophily rate of each group tend to come nearer. We then may assume that when determinents of SN formation have not the same value for members of the minority and the majority groups, this situation with advantaged for the minority could change. If homophily is higher for members of the minority than for members of the majority, homophily will maybe benefit to members of the majority. Of course, as our model is complex and many things can occur, this situation should be studied in additional simulations.

*Explanation for the non-monotonicity of the job arrival rates curve:*

Following C-A&Z and I&S, we have assumed a binomial distribution of unemployment into networks -see equation (9). Looking into this distribution we observe that there are the same variables -$u_{ei}$ and $l_i$- in the numerator and the denominator though operations with these variables are not identical. A rise in $H_i(n_i)$ will obviously have the same consequences on the variation of $u_{ei}$ in each part of the expression but the variation of $u_{ei}$ will not have the same impact on the denominator and the nominator. We observe that a positive variation in $H_i(n_i)$ may have a higher impact on the numerator untill a fixed value $\overline{H}_i(n_i)$ and then a higher impact on the denominator. In other words, not only the minority is advantaged when $H_i(n_i) > n_i$ but the situation of the minority is improved until some openness $\overline{H}_i(n_i)$ of the network and then deteriored. The fact that unemployment is distributed at random in each networks allow for an increasing and decreasing impact of homophily rate.

#### *3.5.4. What about the impact of variations in $\gamma$, $\beta$ and $n_i$ on job arrival rate and unemployment?*

Fig.3 is sufficient to compare the effect of preferences, meeting biases and relative size of the group on job arrival rate for members of the minority group.

*The impact of a variation in preferences for same type ties $\gamma$ on job arrival rates:*

When comparing the case with "medium biases" -black dashes- and the case with "strong preferences and medium biases in meetings" -gray dashes, one may observe that the situation of members of the minority group is depreciated when preferences rises. This could even hamper frienship formation for individual from very little group (see Fig.2) and globally disadvantage members of the minority group in comparison with members of the majority group. In other works it could counterbalance the positive effect of biased homophily for minority and inverse the global effect. However, this is all in all in line with the very few existing empirical works on the subject -see for instance Battu & al (2010). It give an additional simple explanation to empirical observations.

*The impact of a variation in meeting biases through same type $\beta$ on job arrival rates:*

As we mentioned, a rise in meeting opportunity biases may be associated to a rise in the global ethnic segregation in the society. When comparing in Fig.3 the case with "medium biases" -black dashes- and the case with "medium preferences and strong meeting biases" -black thick solid, one may observe that the situation of members of the minority group has moved in a positive direction. Looking into Fig.1, one may conclude that this is due to the existance of biased homophily. In fact this rise the difference between tahe average homophily rate of the majority group and the minority, particularly for little $n_i$ -for very little relative size of the minority group. These results also are in line with the empirical literature which is a little more developed in this area -see for instance Damm (2009), Hellerstein & al (2008), Pattachini & Zenou (2008), Edin & al (2003) and Conley & Topa (2002).

*The impact of a variation in the relative size of groups on job arrival rates:*

From Fig.3 we see that a rise in the average size of the minority group always has -when biases exist- a positive and then negative effect on job arrival rates for members of the minority group. This is conversely true for members of the majority group. There is not any empirical study to our knowledge which explore this correlation, excepted the one of Munshi (2003) which works on very rich data on Mexican migrant in the US. But if this link seems to be robust there is not any clear interpretation emerging from this study.

### 3.6. The labor market with discrimination

We now consider that members of the minority group will be exogenously confronted to hiring discrimination. Indeed, as suggested by Arrow (1998), the impact of SN on labor market for minority and hiring discrimination should not be studyied separatly. This remark could be taken as something judicious to do in our model as when members of the minority are subjected to hiring discrimination, having more link with individual from the minority will increase the number of unemployed contacts and the lower the probability to get information on job vacancies through SN.

If $i$ is the minority, we have the same model as before excepted that

$$p_i = Dv + (1 - Dv)\, D\varphi_i \tag{28}$$

with $D \in [0,1]$. Equation (13) is not affected. Moreover let us mention that the parameter $D$ do not interfere in the probability $v$ of an employed individual of type $i$ to hear about a job vacancy -see this probability $v$ in both equations (10) and (11). In fact, when he is employed, a member of the minority group just hear of a vacancy in his firm and transmit the information. He will be discriminated against only if he apply for the job. In the same way as before we choose a set of value for $\gamma$ and $\beta$ but this time taking into account equation (28) instead of equation (12).

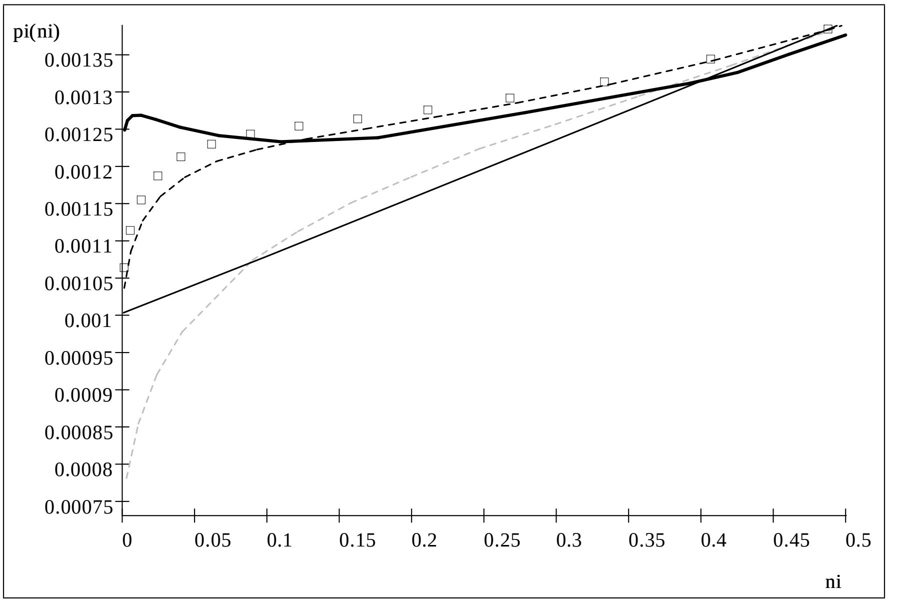


Fig.5 Job arrival rate for minority with D=0.5

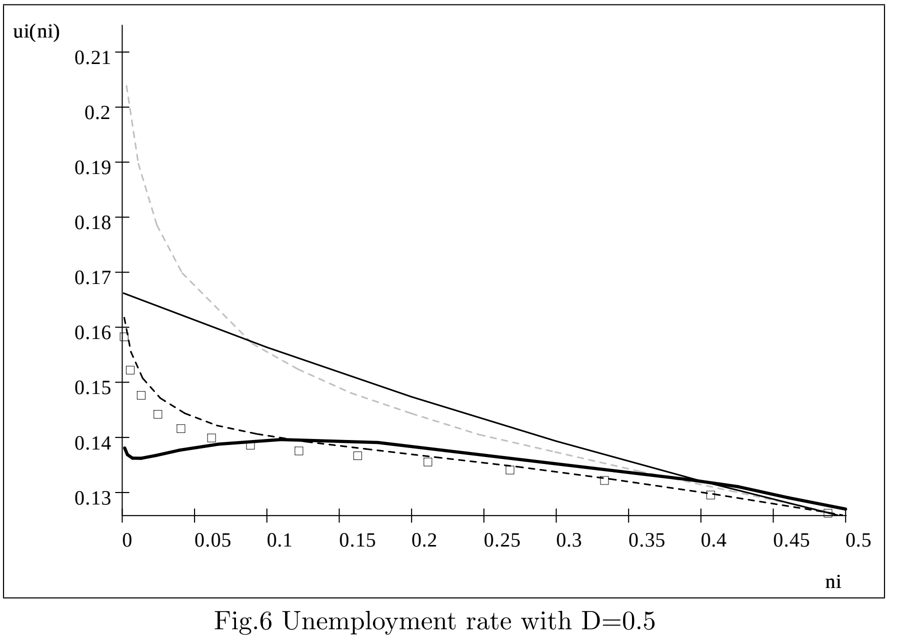


Fig.6 Unemployment rate with D=0.5

**No biases** (black thin solid) : $\gamma = 1$ & $\beta = 1$

**Medium biases** (black dashes) : $\gamma = 0.8$ & $\beta = 2$

**Strong pref. and medium biases in meeting** (gray dashes) $\gamma = 0.1$ & $\beta = 2$

**Medium pref. and strong biases in meeting** (black thick solid) $\gamma = 0.8$ & $\beta = 5$

**Only biases in meeting** (boxes) $\gamma = 1$ & $\beta = 2$

### 3.6.1. *The main observations*

We first observe that this time, when members of the minority are subjected to hiring discrimination, the situation of the minority is worse than the one of the majority. Discrimination seems to have a larger effect than the positive one of SN with homophily when discrimination exist. Indeed, as we see in Fig.5, biased homophily still have[24] a positive impact on job arrival rate for the minority.

Let us concentrate on the situation without any biases. Unlike the case without discrimination, there is now an impact of SN on labor market outcomes even when there are not any biases (the case in black thin solid, $\gamma = 1$ and $\beta = 1$). Job arrival rate for the minority $p_i$ rises with homophily rate $H_i$. Why is it so? Something noteworthy is that when there are not any biases, individuals of type $i$ and $j$ have the same amount of contact of each type. Differences between the two groups[25] then only come from the different size of the group. Thus when the size of each group tend to be closer, the situation of the minority is improving. In fact, as members of the minority group are discriminated against in the hiring process, having more link from the minority group in his SN will reduce the ability of the network to provide information about vacant job[26]. When relative size of the minority group $n_i$ rises, the number of contacts from the minority rises in both SN of individuals of type $i$ and $j$, but it has a larger negative effect in networks of individual of type $i$. The relative situation of the minority is going better in comparison with the situation of the majority which is going worse.

Looking into the other cases with biased homophily in SN, one may notice that the order of the results has not changed in comparison with the case without discrimination, excepted in the case when there are strong biases in meeting (black thick solid, $\gamma = 0.8$ & $\beta = 5$). In this latter case, the very high homophily rate we observe in Fig.1 make the black thin curve varying differently. Having a high level of segregation in the network may create a higher positive effect for very small groups and then a negative effect until regain a low positive effect. The mechanism seams to be much more complicated when homophily in SN is combined with hiring penalty for members of the minority group.

## 4. CONCLUDING REMARKS

Heterogeneity in our model comes from variations in both homophily rate and average number of contacts by individual in each group. Our numerical simulations are mainly in

[24] Excepted in the case with high meeting opportunity biases in black thick solid, $\gamma = 0.8$ & $\beta = 5$.
[25] Excepted the exogenous steady rate of hiring discrimination $D$.
[26] Hiring discrimination rises unemployment rate for members of the minority group (see unemployment rate in Fig.6 for members of the minority group in comparison with the average unemployment rate in the economy which is fixed at 10%).

line with theoretical and empirical works which have investigated the impact of variations in the average number of contacts each individual has on labor market performances. Job arrival rate is increasing in the number of contacts. Our results are however, for the issue of how homophily influence labor market outcomes, partly different from other works. Indeed, unlike T&M's experiment, which constitute as far as we aware one of the very few attempts to study this issue, we consider that homophily in SN vary with the size of the groups. Homophily is then, all other things being equal between the two groups, higher for the majority group. The minority group will be in some way relatively more opened and thus more able to receive informations through SN. Taking into account endogenous homophily in a simple matching model of the labor market with word-of-mouth communication allow us to release the constraints[27] assumed by T&M for homophily to be at the advantage of members of the minority group.

Some additional remarks may be made. First, introducing a model of network formation into a model of the labor market with SN allow us to compare some of our results with empirical studies which try to identify how some social patterns influence both SN and labor market outcomes for various groups of individuals with migrant filiation in the society. Our results are mainly in line with empirical results which show that a rise in preferences for same type ties damages the situation of the minority whereas a rise in meeting opportunity through same type -for instance average ethnic segregation in the society such as urban ethnic segregation[28], improves labor market outcomes for members of the minority group. The other important remark about our model is that the effect of homophily for members of the minority group remains positive since members of the minority group are affected by an exogenous hiring penalty. Indeed, the existence of hiring discrimination could have transformed the positive effect of biased homophily for members of the minority group into a negative effect: having more links coming from the minority group would increase the number of unemployed contacts, which would thus decrease the number of potential sources of information and increase the competition for information in the network. But as homophily grows with the relative size of the minority group, the relative part of contacts from the minority also rises in members of the majority[29]'SN. The majority group is more affected by this phenomenon than the minority. However, the effect of hiring discrimination for the minority is in our simulations, even with a low level of discrimination, by far larger than the positive effect of biased homophily for the minority group. This latest remark allow us to assume that our theoretical scenario offers a potential explanation for the difference in the average level of unemployment observed in France between North African orginated workers, French

[27] In T&M this clearly works only when members of the minority group are tied into little clusters whereas members of the majority group are randomely tied. Jobs must also be organized into networks and not be independant each other.

[28] See for instance Damm (2009), Hellerstein & al (2008), Pattachini & Zenou (2008), Edin & al (2003) and Conley & Topa (2002).

[29] When the relative size of the minority group increase, both the relative size and the average homophily rate are decreasing for the majority group.

workers and Portuguese originated workers[30] (see Domingues Dos Santos, 2005).

Finally, ethnic oriented homophily being one of the most significant pattern of SN according to many empirical studies, we think that the consequence of biased homophily in SN on market mechanisms should in the future generate more attention. We need more theoretical and empirical explorations to clarify the consequences of homophilous behaviors on many observed features of the labor market. By introducing homophily in SN in a dynamics framework[31], one could for instance try to explain why the edge of a giving group of migrant workers or workers with migrant filiation in a labor pool matters a lot as Patel and Vella (2007), Frijters & al (2005) and Munshi (2003) have empirically observed. Other future researches may also go further in analysing the structure of networks by using graph theory as in Càlvo-Armengol & Jackson (2004). Graph theory could for instance be used to introduce clusters[32] in SN -little groups of individuals all tied together. But instead of T&M, clusters should not be exogenously introduced in a model with homophily in SN. Indeed, if clusters modify information circulation -see Jackson (2008a)- and it has been shown -see Jakson (2008b)- that biased-homophily increases clustering in networks. A latest remark may be made about the introduction of jobs networks. Unlike T&M, something which could be interesting to take into account is the fact that jobs are most of the time linked in function of their quality[33]. Someone who works in a good job will more often heard about an offer on a good job vacancy than someone who work in a bad job. Moreover, someone employed in a bad job will rationally keep the information for him in order to improve his situation. Thus, as homophily in SN influence information transfer, one should study in which conditions it makes some groups more able than others to get good jobs.

[30] Portuguese workers have on average the lowest rate of unemployment, even lower than the one of French workers. Portuguese workers could then be identified in our model to members of the minority group when they are not discriminated against, whereas North African worker may be assimilated to discriminated members of the minority group.

[31] See Fontaine (2008) for a theoretical model with a dynamic evolution of employment into networks.

[32] Non-randomness -which in some way reflects clustering or the fact that individuals make ties with friends of friends- have been taking into account by Tassier and Menzcer (2008) but without taking into account any link between homophily rate and randomness as it should be done according to Jackson (2008a, 2008b).

[33] Quality of jobs may refer to working conditions, wages or any advantages which could improve workers satifaction. See for instance the paper of Pissarides (1994) about bad jobs and good jobs.

# 5. REFERENCES

Arrow K. (1998) "What Has Economic to Say about Racial Discrimination?" *Journal of Economic Perspectives*, 12(2), p.91-110.

Battu, H. and Y. Zenou (2010), « Oppositional identities and employment for ethnic minorities. Evidence from England », *Economic Journal*, forthcoming.

Battu H., M. McDonald and Y. Zenou (2007), « Oppositional identities and the labor market », *Journal of Population Economics*, 20, p.643-667.

Càlvo-Armengol A. and M. Jackson (2004) "Social Networks in determining employment: patterns, dynamics and inequality", *American Economic Review*, 94, p. 426-454.

Càlvo-Armengol A. and Y. Zenou (2005) "Job Matching, Social Network and Word-of-Mouth Communication, *Journal of Urban Economics*, 57, p.500-522.

Conley T.G. and G. Topa (2002) "Socio-Economic distance and spatial patterns in unemployment", *Journal of Applied Econometric*s, 17, p.303-327.

Currarini S., M. Jackson and P. Pin (2008) "An economic model of friendship: homophily, minorities and segregation", *Econometrica*, Vol.77, N°4, p.1003-1045.

Damm, A.P. (2009) "Ethnic Enclaves and Immigrant Labor Market Outcomes: Quasi-Experimental Evidence", *Journal of Labor Economics*, 27(2), p.281-314.

Domingues Dos Santos M. (2005) « Travailleurs Maghrébins et Portugais en France : le poids de l'origine », *Revue Economique*, Vol 56, p.447-464.

Edin P-A., P. Fredriksson and O. Aslund (2003) "Ethnic enclaves and the economic succes of immigrants-Evidence from a natural experiment", *Quarterly Journal of Economics*, 118, p.329-357.

Fontaine F. (2008) "Why are similar workers paid differently? The role of social networks.", *Journal of Economic Dynamics and Control*, vol. 32, issue 12, p.3960-3977.

Frijters P. Shields M.A. and Wheatley Price S. (2005) "Job search methods and their succes: a comparison of immigrants and natives in the UK", *The Economic Journal*, 115 (November).

Granovetter M. (1973) "The Strength of Weak Ties", *American Journal of Sociology*, Vol.78, N°6, p.1360-1380.

Grosseti M. (2007) "Are French network different?", *Social Network*, 29, p.391-404.

Hellerstein J.K., M. McInerney & D. Neumark (2008) "Neighbors and Co-Workers: the Importance of Residential Labor Market Networks", *NBER-WP*, N°14201.

Holzer H. (1987) "Informal Job Search and Black Youth Unemployment", *American Economic Review*, Vol. 77, N°3.

Ioannides Y. and L. Datcher Loury (2004) "Job information Networks, Neighborhood effects and Inequality", *Journal of Economic Literature*, 42(4), p.1056-1093.

Ioannides Y. and Soetevent A. (2006) "Wages and Employment in a random Social Network with Arbitrary Degree Distribution", *American Economic Review*, Vol. 96, N°2.

Jackson M. (2008a) "Social and Economic Networks", Princeton University Press.

Jackson M. (2008b) "Average Distance, Diameter, and Clustering in Social Networks with Homophily", Proceedings of the Workshop in Internet and Network Economics (WINE 2008).

Lewis K., J. Kaufman, M. Gonzalez, A. Wimmer and N. Christakis (2008) "Tastes, ties, and time: A new social network dataset using Facebook.com", *Social Network*, 30, p.330-342.

Marsden P. (1988) "Homogeneity in confiding relations, *Social Network*, 10, p.57-76.

McPherson M., L. Smith-Lovin & J.M. Cook (2001), "Birds of a Feather: Homophily in Social Networks", *Annual Review of Sociology*, 27, p.415-444.

Moody J. (2001) "Race, School Integration, and Friendship Segregation in America", *American Journal of Sociology*, Vol.107, N°3, p.679-716.

Munshi K. (2003) « Networks in modern economy: Mexican migrants in the US Labor Market", *Quarterly Journal of Economics,* May 2003, p.549-599.

Patacchini E. and Zenou Y. (2008) "Ethnic Networks and Employment Outcomes", *IZA Discussion Paper* n°3331.

Patel K. and Vella F. (2007) "Immigrant Networks and their implications for occupational Choice and Wages", *IZA Discussion Paper* n°3217.

Pissarides C. (2000) "Equilibrium Unemployment Theory", Cambridge, Massachussetts: MIT Press, 2nd Edition.

Pissarides C.A. (1994) "Search Unemployment with On-the-job Search", *Review of Economic Studies*, 61, p.457-475.

Rees A. (1966) "Information networks in Labor Markets", *American Economic Review*, 56, p.559-566.

Tassier T. & F. Menczer (2008) "Social Network Structure, Segregation, and Equality in the Labor Market with Referral Hiring, *Journal of Economic Behavior & Organization*, Vol.66, p.514-528.

Wahba J. and Y. Zenou (2005) “Density, social networks and job search methods: theory and application to Egypt”, *Journal of Development Economics*, 78, p.443-473.

## APPENDIX A: THE CHOICE OF PARAMETERS

As Fontaine (2008), we choose the following value corresponding to the French economy:

If $r$ is the daily interest rate, we choose $r = 0.00016$.

$b$, the daily job destruction rate is fixed such that $b = 0.0002$.

The bargaining power of workers $x$ is as usual $x = 0.5$.

The cost of a vacant job is estimated to 0.3, the $h = 0.3$.

We fix the global unemployment rate $u = 0.1$.

As in C-A&Z and I&S, productivity of workers is normalized to 1, then $y_1 = 1$. Moreover $y_0$ is fixed to 0.

## APPENDIX B: INTRODUCING A PARAMETER "**A**" TAKING INTO ACCOUNT INSTUTIONNAL SPECIFICITIES MAKING $U = 0.1$

Let us add to the matching function $m(u_i, u_j, v, n_i) = n_i u_i p_i + (1 - n_i) u_j p_j$ we have in the model, a parameter $A$ such that

$$m(u_i, u_j, v, n_i) = A(n_i u_i p_i + (1 - n_i) u_j p_j)$$

Let now determine the value of $A$ when $u = 0.1$ is fixed.

(1) Starting from $u$, we have $u = \frac{b}{(1-b)p+b}$ which imply $p = \frac{b(1-u)}{(1-b)u}$.

(2) On another hand we have $p = A\left(\frac{n_i u_i}{u}(v + (1-v)\varphi_i) + \frac{(1-n_i)u_j}{u}\left(v + (1-v)\varphi_j\right)\right)$.

From (2) we deduce that

$$p = A\left(\frac{n_i u_i}{u}(v + (1-v)\varphi_i) + \frac{(1-n_i)u_j}{u}\left(v + (1-v)\varphi_j\right)\right)$$

$\iff$

$$p = A\left(\frac{n_i u_i}{u}v + \frac{n_i u_i}{u}(1-v)\varphi_i + \frac{(1-n_i)u_j}{u}v + \frac{(1-n_i)u_j}{u}(1-v)\varphi_j\right)$$

$\iff$

$$p = A\left(v + \frac{(1-v)}{u}\left(n_i u_i \varphi_i + (1-n_i)u_j\varphi_j\right)\right)$$

$\iff$

$$A = \frac{p}{v + \frac{(1-v)}{u}\left(n_i u_i \varphi_i + (1-n_i)u_j\varphi_j\right)}$$

and from (1), we have

$$A = \frac{\frac{b(1-u)}{(1-b)u}}{v + \frac{(1-v)}{u}\left(n_i u_i \varphi_i + (1-n_i)\, u_j \varphi_j\right)}$$

## APPENDIX C: INTRODUCING A PARAMETER "A" TAKING INTO ACCOUNT INSTUTIONNAL SPECIFICITIES MAKING $U = 0.1$ WHEN DISCRIMINATION EXIST

As above without discrimination, we determine the value of $A$ when $u = 0.1$ is fixed.

In the same way as above, we have
(1) $u = \frac{b}{(1-b)p+b}$ which imply $p = \frac{b(1-u)}{(1-b)u}$,
but now if type $i$ stands for the minority and as members of the minority group are discriminated against at rate $D \in [0,1]$, we do not have (2) but
(2bis) $p = A\left(\frac{n_i u_i}{u}\left(Dv + (1-Dv)\, D\varphi_i\right) + \frac{(1-n_i)u_j}{u}\left(v + (1-v)\,\varphi_j\right)\right)$.

Starting from (2bis) we have

$$A = \frac{p}{\frac{n_i u_i}{u}\left(Dv + (1-Dv)\, D\varphi_i\right) + \frac{(1-n_i)u_j}{u}\left(v + (1-v)\,\varphi_j\right)}$$

$\Longleftrightarrow$

$$A = \frac{p \times u}{n_i u_i\left(Dv + (1-Dv)\, D\varphi_i\right) + (1-n_i)\, u_j\left(v + (1-v)\,\varphi_j\right)}$$

and introducing (1) we find

$$A = \frac{\frac{b(1-u)}{(1-b)u} \times u}{n_i u_i\left(Dv + (1-Dv)\, D\varphi_i\right) + (1-n_i)\, u_j\left(v + (1-v)\,\varphi_j\right)}$$

$\Longleftrightarrow$

$$A = \frac{b\,(1-u)}{(1-b)\left(n_i u_i\left(Dv + (1-Dv)\, D\varphi_i\right) + (1-n_i)\, u_j\left(v + (1-v)\,\varphi_j\right)\right)}$$